Improved lensing reconstruction with a non-parametric code

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Main idea

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- we integrate physical priors in the code: contribution to the deflection field coming from the galaxies of the cluster.
- new code is tested with simulated data (strong lensing) that mimics real data
- It greatly help to increase the resolution of the solution and reduce the uncertainties.
Non-parametric code:

\[
\text{Approximation: split lens in } N_c \text{ cells:
} \sum_{i=1}^{N_c} c_i f_i(\theta) \\
\text{Deflection map:
} \alpha(\theta) = 4 GD LS c^2 D S D L \sum_{i=1}^{N_c} c_i \int f_i(\theta') \theta - \theta' \parallel \theta - \theta' \parallel^2 \\
\text{The problem:
} \text{a linear system of } 2N_\theta \text{ equations and } (2N_S + N_C) \text{ unknowns:
} \Theta = \Gamma x \rightarrow \Theta = \Upsilon x I x 0 \Upsilon y 0 I y \times \begin{pmatrix} c \beta_x \\ c \beta_y \end{pmatrix}
\]

Approximate solution → residual equation: \( r \equiv \Theta - \Gamma x \).
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$\alpha_i = \gamma_{ij} c_j$
Improved SLAP code

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SLAP code

Improved SLAP code

Results

Conclusions

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\[ \alpha_i = \gamma_{ij} c_j \]

▶ The problem: a linear system of \( 2N_\theta \) equations and \((2N_S + N_C)\) unknowns:

\[ \Theta = \Gamma x \rightarrow \begin{bmatrix} \theta_x \\ \theta_y \end{bmatrix} = \begin{bmatrix} \gamma_x & I_x & 0 \\ \gamma_y & 0 & I_y \end{bmatrix} \times \begin{bmatrix} c \\ \beta_x \\ \beta_y \end{bmatrix} \]
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- User defines a number of halos and their characteristics \( \{(x, y), M[10^{15} h^{-1} M_{\odot}], r_{\text{soft}}, r_s, (e_x, e_y, e_z)\} \)

Useful for pedagogical reasons and when analysing real data to identify possible bias and add confidence to results.
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→ We will use these tool to obtain the deflection field of the cluster galaxies.
Cluster galaxies contribute with a mass proportional to a fiducial value whose proportionality constant is later inferred as a part of the method.

Compute $\alpha_{\text{gal}}$:

$L \rightarrow M \rightarrow R$

$\{(x, y), M, R\} + \text{WSLAP code simulating tool}$

New column in $\Gamma$ matrix given by $\alpha_{\text{gal}}$.

New unknown, $c_{\text{gal}}$, proportionality constant.

New system of equations:

$$\begin{bmatrix} \theta_x & \theta_y \end{bmatrix} = \begin{bmatrix} \Upsilon_x \alpha_{\text{gal}}, x I x_0 \Upsilon_y \alpha_{\text{gal}}, y_0 I y \end{bmatrix} \times \begin{bmatrix} c & c_{\text{gal}} \beta_x \beta_y \end{bmatrix}$$

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\end{bmatrix} = \begin{bmatrix}
\gamma_x & \alpha_{\text{gal},x} & I_x & 0 \\
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\end{bmatrix} \times \begin{bmatrix}
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c_{\text{gal}} \\
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\]
Recomposed critical curves

Simulated cluster
Results

Recomposed critical curves

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SLAP old version
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Improved SLAP

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**Results**

Recomposed mass profile

Figure: **Thick lines** → real/simulated case, **dotted lines** → new version of SLAP, and **dashed lines** → old version of SLAP
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Conclusions

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- Next step: Apply this new version of the code to real clusters.
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- **Next step:** Apply this new version of the code to real clusters.

- This new version of the code based in a non-parametric approach will also provide an important consistency check for the parametric approach, since concurring results will strengthen their validity, whereas any resulting differences would need to be addressed.